

## **DESTRUCTIVE EXPENDABLES**

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## **ABSTRACT**

Phase II of the Laser Beamrider Countermeasures program is complete. Phase II consisted of static tests where anti-aircraft missiles were exposed to detonating 40mm and 70mm warheads. All of the tested missiles received significant damage. Also some dynamic tests occurred where the effects of these detonating warheads on the flights of missiles were observed. For those tests where the detonations were properly timed the missiles failed to reach the target.

## **1.0 INTRODUCTION**

AFRL/SNJ is pursuing the concept of an aircraft self-protection system that uses a destructive expendable to destroy any and all anti-aircraft missiles. This concept was first presented to this conference in 1996 by Lt. Col. Stuart Kramer, PhD. He reported on the results of a system study conducted by the Systems Engineering class at the Air Force Institute of Technology. The concept is straightforward. Ideally, existing missile warning hardware, existing missile tracking hardware and existing dispenser hardware would be used. The only new item would be the destructive expendable, which would be compatible with existing dispensers. The destructive expendable would be robust in that it will destroy any and all anti-aircraft missiles that might attack any and all aircraft. In 1996 the Laser Beamrider program was started to explore the viability of this ideal concept in defeating laser beamriders. In 1998, at this IRIS/IRCM conference held at Eglin AFB, the results of the simulation/study/analysis phase of the beamrider program were presented. This paper presents the results of the test phase of this program.

## **2.0 LBR PROGRAM SUMMARY**

Lockheed Martin Naval Electronics & Surveillance Systems - Akron under contract to the United States Air Force Research Laboratory conducted the Laser Beamrider program. In the first phase of this two phase program five main tasks were performed: (1) threat data review, (2) susceptibility analysis, (3) countermeasure concept development, (4) trade-off studies, (5) preliminary system design. The destructive expendable, countermeasure system analyzed consists of the following subsystems: missile warning, tracker, fire control computer, trainable launcher, and expendable mini-rockets with blast/fragmentation warheads. These studies resulted in the preliminary design of a 39mm, rocket propelled, controlled fragmentation warhead expendable which is about the size of an MJU10 flare. Based on several simplifying assumptions, it was estimated that the probability of

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success of the 39mm, destructive expendable destroying a laser beamrider missile is approximately 0.95. This missile has the average dimensions of four inches in diameter by three feet long. At the point of destruction, the separation distance between the expendable and the laser beamrider missile is one meter or less. The work performed during the first phase of the program was documented in an interim report (reference [1]).

These studies were followed in the second phase of the program with a limited number of tests of a warhead that simulated the proposed countermeasure warhead of the proposed destructive expendable. Static and dynamic tests using small blast/fragmentation warheads were conducted to examine their effectiveness against representative threats. The arena tests were structured to help assess the effectiveness of compact, blast/fragmentation warheads against different parts of a missile, warheads, and inert guidance & control sections. The live-fire missile tests were devised to assess the effects of the statically mounted warheads on threat missiles flying by.

### **3.0 SUMMARY OF DESTRUCTIVE EXPENDABLE WARHEAD TESTS**

Static arena tests and live-fire missile engagement tests, where the warhead was static, were performed to assess the effectiveness of small blast/fragment warheads against anti-aircraft missiles. The tests were performed using two warheads, the 40mm Bofors Mark II and the 70mm M151HE, that would be close approximations to a possible destructive expendable warhead. In the static arena tests, entire AIM-4 missiles, guidance & control sections of Redeye missiles, guidance & control sections of a foreign missile, Redeye warheads, and warheads from a foreign missile were used as targets.

In the live-fire missile engagement tests, the stationary destructive expendable warheads were tested against AT-4 rockets and TOW missiles. While these last two missiles are not anti-aircraft missiles, the behavior of these missiles, as affected by the exploding destructive expendable warhead, should approximate the behavior of anti-aircraft missiles.

The results of all the tests are consistent and show that both of the selected warheads can cause significant structural and/or component damage to the threats.

### **4.0 STATIC WARHEAD TESTS**

The static warhead arena tests were performed using two warheads that were available and obtained from the U. S. Army inventory: the 40 mm Bofors Mark II and the 70 mm M151HE warheads. Both warheads have naturally fragmenting cases, and the 40mm warhead also contains 650 tungsten spheres. These warheads were initiated using C-4 explosive pressed into the fuse well and RP-80 or RP-83 detonators. The 40mm warhead closely approximates the size of the 39mm destructive expendable proposed in the study phase of this program.

Two sets of static warhead arena tests were performed at NAWC, China Lake. The first set consisted of tests of the destructive expendable warheads against warheads taken from anti-aircraft missiles. The selected threat warheads were from Redeye missiles and a foreign missile. In these tests, the missile warheads were placed at selected distances surrounding the detonating destructive expendable warhead. The effects of the destructive

expendable warheads on the missile warheads could then be examined as a function of separation distance.

The second set of static warhead arena tests consisted of one test of each destructive expendable warhead. Twelve inert missiles were placed around the exploding destructive expendable warhead at distances from one third to two meters. The selected inert missiles were six AIM-4's, three Redeye's, and three foreign missiles in each of the two tests. All explosive devices had been removed from these missiles to avoid any sympathetic detonation, thus allowing the inclusion of multiple missiles in a single test. The effects of the two destructive expendable warheads on the guidance and control sections of the threat missiles could then be assessed as a function of separation distance. The test items were placed so that the effects of ground blast reflections would be minimal.

In the remaining paragraphs, the following definitions are used:  
Catastrophic structural damage: breakup of missile.  
Significant structural damage: damage that is non-trivial but doesn't break up the missile.  
Catastrophic component damage: fragments penetrate outer skin and destroy internal components.  
Significant component damage: fragments penetrate outer skin and impacted internal components.

The static arena test of the 40mm warhead showed that it could inflict catastrophic component damage to the guidance and control sections of the threat missile at distances up to at least one meter. Significant component damage can be inflicted at distances up to approximately two meters. Since significant structural damage was not inflicted, detailed examination of component damage and its effects on missile performance would be required to assess/estimate the effectiveness of the 40mm warhead in defeating the threat missiles.

The static arena tests of the 40mm warhead against the two missile warheads showed that it was not effective in destroying or initiating the threat warheads at least at distances greater than one third meter. However, in an actual missile engagement the fragment impact velocity could be higher, which might increase the likelihood of sympathetic detonation.

The structural damage inflicted by the selected 40mm warhead was not significant at one meter, but it caused catastrophic component damage that can result in the threat missile not being able to complete its mission. At separation distances of about one half meter or less the 40mm warhead inflicts catastrophic damage.

The static arena test of the 70mm warhead showed that it could inflict catastrophic structural damage to the guidance and control sections of the threat missiles at distances up to at least one meter. It can safely be stated that any typical missile within one meter of the 70mm warhead would be most likely destroyed. Significant structural and component damage can be inflicted at distances up to at least two meters.

At separation distances of a meter or less, the 70mm warhead inflicts catastrophic structural damage. The 70mm warhead was able to achieve direct initiation or burning of target warheads.

## 5.0 LIVE FIRE TESTS

The live-fire missile tests were performed at Redstone Arsenal to assess the effects of blast and fragmentation from the two destructive expendable warheads on two flying surrogate threat missiles: the Basic TOW and the AT-4 rocket. One test of each destructive expendable warhead against each missile threat was performed. The destructive expendable warhead was stationary and was detonated when the flying missile passed by it on its way to a target 100 m away.

The live-fire missile tests are summarized in Table 1.

CM Warhead	Threat	Threat Speed [m/sec]	Separation Distance [m]	Result
40mm Mark II	AT-4	259	0.7	Late detonation; No effect; AT-4 impacted its target
70mm M151HE	AT-4	269	0.9	AT-4 exploded in mid-flight
40mm Mark II	TOW	222	0.7	TOW damaged; Impacted 10 m left of target center
70mm M151HE	TOW	224	1.2	TOW exploded in mid-flight

Table 1. LBRM CM Live-Fire Tests

The 40mm warhead did not alter the flight path of the unguided AT-4 rocket that successfully continued its flight towards its target. However, close review of photographic instrumentation shows that the warhead detonation occurred after the missile had passed. On the test against the TOW missile, the 40mm warhead apparently inflicted sufficient damage to the TOW missile that caused it to alter its flight path drastically and impact 10 m away from its intended target. Analysis of the test geometry and the aerodynamic capabilities of the TOW shows that the TOW could not have performed that maneuver if it was operating normally.

The 70mm warhead was successful against both the AT-4 rocket and the TOW missile; it caused the warheads of both threats to explode in flight.

## 6.0 CONCLUSIONS

The number of tests performed during the second phase of this program was definitely not large enough to establish a statistical basis that would be sufficient for quantifiable conclusions. However, the results of both the static warhead arena tests and the live-fire missile tests appear to be consistent:

1. The 40mm warhead caused significant damage to the guidance and control sections of threat missiles at distances of one meter or

less. In the live-fire test against the TOW missile such damage resulted in the TOW missing its target.

2. The 70mm warhead was destructive to both the warhead and guidance and control sections of the tested threats at distances of one meter or less in both the static and live fire tests.

The test results show clearly that a direct hit is not required to defeat an anti-aircraft missile of small to medium size. If complete destruction of the threat missile is desired, it can be achieved by detonating a warhead similar to the tested 70mm M151HE warhead within one meter of the threat missile. A warhead similar to the tested 40mm Mark II warhead would be sufficient to produce significant component damage to the guidance and control sections, if detonated within one meter of the threat missile.

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